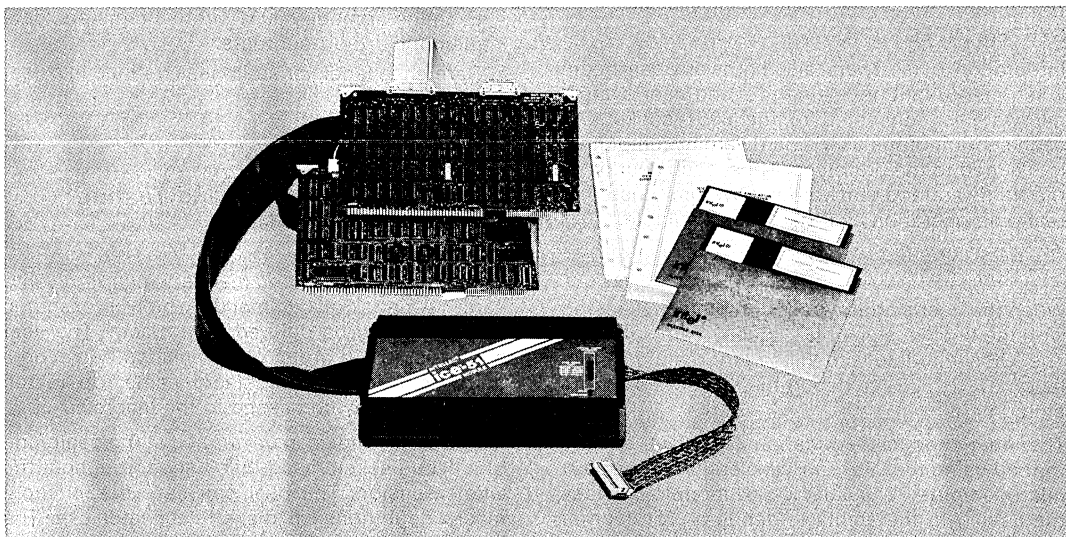




ICE-51™ 8051 IN-CIRCUIT EMULATOR

- **Precise, full-speed, real-time emulation**
 - Load, drive, timing characteristics
 - Full-speed program RAM
 - Serial and parallel ports
- **User-specified breakpoints**
- **Execution trace**
 - User-specified qualifier registers
 - Conditional trigger
 - Symbolic groupings and display
 - Instruction and frame modes
- **Emulation timer**
- **Full symbolic debugging**
- **Single-line assembly and disassembly for program instruction changes**
- **Macro commands and conditional block constructs for automated debugging sessions**
- **HELP facility: ICE-51 command reference at the console**
- **User confidence test of ICE-51 hardware**

The ICE-51 module resides in the Intellec® Microcomputer Development System and interfaces to any user-designed 8051 system through a cable terminating in an 8051 emulator microprocessor and a pin-compatible plug. The emulator processor, together with 8K bytes of user program RAM located in the ICE-51 buffer box, replaces the 8051 device in the user system while maintaining the 8051 electrical and timing characteristics. Powerful Intellec debugging functions are thus extended into the user system. Using the ICE-51 module, the designer can emulate the system's 8051 in real-time or single-step mode. Breakpoints allow the user to stop emulation on user-specified conditions, and a trace qualifier feature allows the conditional collection of 1000 frames of trace data. Using the single-line 8051 assembler the user may alter program memory using ASM51 mnemonics and symbolic references, without leaving the emulator environment. Frequently used command sequences can be combined into compound commands and identified as macros with user-defined names.



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FUNCTIONAL DESCRIPTION

Integrated Hardware and Software Development

The ICE-51 emulator allows hardware and software development to proceed interactively. This approach is more effective than the traditional method of independent hardware and software development followed by system integration. With the ICE-51 module, prototype hardware can be added to the system as it is designed. Software and hardware integration occurs while the product is being developed.

The ICE-51 emulator assists four stages of development:

SOFTWARE DEBUGGING

It can be operated without being connected to the user's system before any of the user's hardware is available. In this stage ICE-51 debugging capabilities can be used in conjunction with the Inteltec text editor and 8051 macroassembler to facilitate program development.

HARDWARE DEVELOPMENT

The ICE-51 module's precise emulation characteristics and full-speed program RAM make it a valuable tool for debugging hardware, including time-critical serial port, parallel port, and timer interfaces.

SYSTEM INTEGRATION

Integration of software and hardware can begin when any functional element of the user system hardware is connected to the 8051 socket. As each section of the user's hardware is completed, it is added to the prototype. Thus, each section of the hardware and software is "system" tested in real-time operation as it becomes available.

SYSTEM TEST

When the user's prototype is complete, it is tested with the final version of the user system software. The ICE-51 module is then used for real-time emulation of the 8051 to debug the system as a completed unit.

The final product verification test may be performed using the 8751 EPROM version of the 8051 microcomputer. Thus, the ICE-51 module provides the user with the ability to debug a prototype or production system at any stage in its development without introducing extraneous hardware or software test tools.

Symbolic Debugging

The ICE-51 emulator permits the user to define and use symbolic, rather than absolute, references to program and data memory addresses; additional symbols are predefined by the ICE-51 software for referencing registers, flags, and input/output ports. Thus, the user need not recall or look up the addresses of key locations in his program as they change with each assembly, or become involved with machine code.

When a symbol is used for memory reference in an ICE-51 emulator command, the emulator supplies the corresponding location as stored in the ICE-51 emulator symbol table. This table can be loaded with the symbol table produced by the assembler during application program assembly. The user can obtain the symbol table during software preparation simply by using the "DEBUG" switch in the ASM51 macroassembler. Furthermore, the user can interactively modify the emulator symbol table by adding new symbols or changing or deleting old ones. This feature provides great flexibility in debugging and minimizes the need to work with absolute memory values.

Through symbolic references in combination with other features of the emulator, the user can easily:

- Interpret the results of emulation activity collected during trace.
- Disassemble program memory to mnemonics, or assemble mnemonic instructions to executable code.
- Examine or modify 8051 internal registers, data memory, or port contents.
- Reference labels or addresses defined in a user program.

Automated Debugging and Testing

MACRO COMMAND

A macro is a set of commands which is given a name. A group of commands which is executed frequently can be defined as a macro. The user can execute the group of commands by typing a colon followed by the macro name. Up to ten parameters may be passed to the macro.

Macro commands can be defined at the beginning of a debug session and then used throughout the whole session. The user can save one or more macro definitions on diskette for later use. The Inteltec text editor may be used to edit the macro file. The macro definitions are easy to include in any later emulation session.

The power of the development system can be applied to manufacturing testing as well as development by writing test sequences as macros. The macros are stored on diskettes for use during system test.

COMPOUND COMMAND

Compound commands provide conditional execution of commands (IF command) and execution of commands repeatedly until certain conditions are met (COUNT, REPEAT commands).

Compound commands may be nested any number of times, and may be used in macro commands.

Example:

```
*DEFINE .I = 0      ; Define symbol .I to 0
*COUNT 100H       ; Repeat the following
                   ; commands 100H times.
..IF .I AND 1 THEN  ; Check if .I is odd
**CBYTE .I = .I    ; Fill the memory at location .I
                   ; to value .I
..END              ; End if structure
*.I = .I + 1       ; Increment .I by 1.
**END             ; Command executes upon
                   ; carriage-return after END
```

(The characters *, ., and .. shown in this example are system prompts which include an indication of the nesting level of compound commands.)

Operating Modes

The ICE-51 software is an Intellec RAM-based program that provides the user with easy-to-use commands for initiating emulation, defining breakpoints, controlling trace data collection, and displaying and controlling system parameters. ICE-51 commands are configured with a broad range of modifiers which provide the user with maximum flexibility in describing the operation to be performed.

EMULATION

The ICE-51 module can emulate the operation of a prototype 8051 system, at real-time speed (1.2 to 12 MHz) or in single steps. Emulation commands to the ICE-51 module control the process of setting up, running, and halting an emulation of the user's 8051-based system. Breakpoints and tracepoints enable the ICE-51 emulator to halt emulation and provide a detailed trace of execution in any part of the user's program. A summary of the emulation commands is shown in Table 1.

Breakpoints

The ICE-51 hardware includes two breakpoint registers that allow the user to halt emulation when specified conditions are met. The emulator con-

tinuously compares the values stored in the breakpoint registers with the status of specified address, opcode, operand, or port values, and halts emulation when this comparison is satisfied. When an instruction initiates a break, that instruction is executed completely before the break takes place. The ICE-51 emulator then regains control of the console and enters the Interrogation Mode. With the breakpoint feature, the user can request an emulation break when his program:

- Executes an instruction at a specific address or within a range of addresses.
- Executes a particular opcode.
- Receives a specific signal on a port pin.
- Fetches a particular operand from the user program memory.
- Fetches an operand from a specific address in program memory.

Table 1. Major Emulation Commands

Command	Description
GO	Begins real-time emulation and optionally specifies break conditions.
BR0, BR1, BR	Sets or displays either or both Breakpoint Registers used for stopping real-time emulation.
STEP	Performs single-step emulation.
QR0, QR1, QR	Sets or displays match conditions for qualified trace.
TR	Specifies or displays trace-data collection conditions and optionally sets Qualifier Register (QR0, QR1).
SY, SY1, SY0	Set and display status of synchronization line outputs or latched inputs. Used to allow real-time emulation or trace to start and stop synchronously with external events.

Trace and Tracepoints

Tracing is used with both real-time and single-step emulation to record diagnostic information in the trace buffer as a program is executed. The information collected includes opcodes executed, port values, and memory addresses. The ICE-51 emulator collects up to 1000 frames of trace data.

This information can be displayed as assembler instruction mnemonics, if desired, for analysis during interrogation or single-step mode. The trace-collection facility may be set to run conditionally or unconditionally. Two unique trace qualifier registers, specified in the same way as break-

point registers, govern conditional trace activity. The qualifiers can be used to condition trace data collection to take place as follows:

- Under all conditions (forever).
- Only while the trace qualifier is satisfied.
- For the frames or instructions preceding the time when a trace qualifier is first satisfied (pre-trigger trace).
- For the frames or instructions after a trace qualifier is first satisfied (post-triggered trace).

Table 2 shows an example of a trace display.

Table 2. Trace Display (Instruction Mode)

*E ALL	FRAME	LOC	CPD	INSTRUCTION	P1	P2	FC	TCVF
0000	0000H	00	MCV	DDPTE,A	00H	00H	FEF	C
0007	0001H	00	MCV	RD,A	00H	00H	FEF	C
0011	0002H	04	CEL	A	00H	00H	FEF	C
0015	0003H	22	PLC	A	00H	00H	FEF	C
0019	0004H	7ECCCC	MCV	C	00H	00H	FEF	C
0027	0007H	02	CIP	C	00H	00H	FEF	C
0031	0008H	00	SURE	A,FC	00H	00H	FEF	C
0035	0009H	0000	POF	00H	00H	00H	FEF	C
0039	000EH	7E3ACE	MCV	00H,A,LINE	00H	00H	FEF	C
0043	000FH	0156	ADPT	0000H	00H	00H	FEF	C

INTERROGATION AND UTILITY

Interrogation and utility commands give the user convenient access to detailed information about the user program and the state of the 8051 that is useful in debugging hardware and software.

Changes can be made in memory and in the 8051 registers, flags, and port values. Commands are also provided for various utility operations such as loading and saving program files, defining symbols, displaying trace data, controlling system synchronization and returning control to ISIS-II. A summary of the basic interrogation and utility commands is shown in Table 3. Two time-saving emulator features are discussed below.

SINGLE-LINE ASSEMBLER/DISASSEMBLER —

The single-line assembler/disassembler (ASM and DASM commands) permits the designer to examine and alter program memory using assembly language mnemonics, without leaving the emulator environment or requiring time-consuming program reassembly. When assembling new mnemonic instructions into program memory, previously defined symbolic references (from the original program assembly, or subsequently defined during the emulation session) may be used in the instruction operand field. The emulator will supply the absolute address or data values as stored in the emulator symbol table. These features eliminate user time spent translating to and from machine code and searching for absolute addresses, with a corresponding reduction in transcription errors.

Table 3. Major Interrogation and Utility Commands

Command	Description
HELP	Displays help messages for ICE-51 emulator command-entry assistance.
LOAD	Loads user object program (8051 code) into user program memory, and user symbols into ICE-51 emulator symbol table.
SAVE	Saves ICE-51 emulator symbol table and/or user object program in ISIS-II hexadecimal file.
LIST	Copies all emulator console input and output to ISIS-II file.
EXIT	Terminates ICE-51 emulator operation.
DEFINE	Defines ICE-51 emulator symbol or macro.
REMOVE	Removes ICE-51 emulator symbol or macro.
ASM	Assembles mnemonic instructions into user program memory.
DASM	Disassembles and displays user program memory contents.
Change/Display Commands	Change or display value of symbolic reference in ICE-51 emulator symbol table, contents of key-word references (including registers, I/O ports, and status flags), or memory references.
EVALUATE	Evaluates expression and displays resulting value.
MACRO	Displays ICE-51 macro or macros.
INTERRUPT	Displays serial, external, or timer interrupt register settings.
SECONDS	Displays contents of emulation timer, in microseconds.
Trace Commands	Position trace buffer pointer and select format for trace display.
PRINT	Displays trace data pointed to by trace buffer pointer.

HELP — The HELP file allows the user to display ICE-51 command syntax information at the Inteltec console. By typing "HELP", a listing of all items for which help messages are available is displayed; typing "HELP <Item>" then displays relevant information about the item requested, including typical usage examples. Table 4 shows some sample HELP messages.

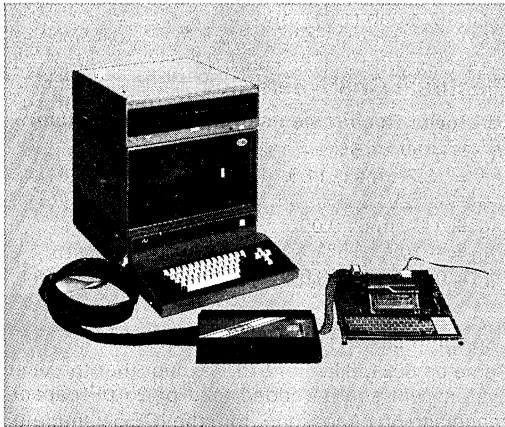


Figure 1. A Typical 8051 Development Configuration. The host system is an Inteltec Model 225, plus 1 megabyte dual double-density flexible disk storage. The ICE-51 module is connected to an SDK-51 system design kit.

Emulation Accuracy

The speed and interface demands of a high-performance single-chip microcomputer require extremely accurate emulation, including full-speed, real-time operation with the full function of the microcomputer. The ICE-51 emulator achieves accurate emulation with an 8051 bond-out chip, a special configuration of the 8051 microcomputer family, as its emulation processor.

Each of the 40 pins on the user plug is connected directly to the corresponding 8051 pin on the bond-out chip. Thus the user system sees the emulator as an 8051 microcomputer at the 8051 socket. The resulting characteristics provide extremely accurate emulation of the 8051, including speed, timing characteristics, load and drive values, and crystal operation. The emulator may draw more power from the user system than a standard 8051 family device.

Additional bond-out pins provide signals such as internal address, data, clock, and control lines to the emulator buffer box. These signals let static RAM in the buffer box substitute for on-chip program ROM or EPROM or external program memory. The 8K bytes of full-speed RAM in the buffer box can be mapped in 4K blocks to anywhere within the 64K program memory space of the 8051. The bond-out chip also gives the emulator "back-door" access to internal chip operation, so that the emulator can break and trace execution without interfering with the values on the user-system pins.

Table 4. HELP Command

```
*HELP
Help is available for the following items. Type HELP followed by
the item name. The help items cannot be abbreviated. (For more
information, type HELP HELP or HELP INEC.)

Emulation:  Trace Collections: Misc:  <address>
CO CR EYF  TR CP CRP CR1 SY)  BASE  <CPU keyword>
BR BRP BRJ  <keyword>  <keyword>
STEP  Trace Display:  ENAPLE  <ICE1 keyword>
          TRACE MCVF PRINT  <identifier>
          OLTEST NEWEST  EVALUATE  <instruction>
          HELP  <masked constant>
Change/Display/Define/Remove:  INEC  <match cond>
<CHANCE>  RMCVCF  CVYTE  PRIT  <numeric constant>
<DISPLAY>  SYMBOL  PRYTE  DASM  <partition>
REGISTER  RESET  PRYTE  ASM  <string>
SECONDS  WRITE  PRYTE  MAP  <string constant>
DEFINE  STACK  XBYTE  EY  SAVE  <symbolic ref>
          <system symbols>
          <trace reference>
          <unlimited fetch cond>
          <user symbols>

Macro:  Define  DIR  Compound
        DISABLE  ENAPLE  Commands:
        INCLUDE  PUT  COUNT
        <MACRO DISPLAY>  IF
        <MACRO INVOCATION>  REPEAT
*
```

```
*HELP IF
IF - The conditional command allows conditional execution of one
or more commands based on the values of boolean conditions.
IF <expr> [THEN] <cr>  <true list>::=if <command> <cr>|p
                        <false list>::=if <command> <cr>|p
                        <command>::=if ICF-F1 command.
                        <true list>|p
                        <false list>|p
                        <true list>|p
                        <false list>|p
                        END
The <expr>s are evaluated in order as 16-bit unsigned integers.
If one is reached whose value has low-order bit 1 (TRUE), all
commands in the <true list> following that <expr> are then
executed and all commands in the other <true list>s and in the
<false list> are skipped. If all <expr>s have value with low-
order bit 0 (FALSE), then all commands in all <true list>s are
skipped and, if FLSE is present, all commands in the <false list>
are executed.
(EY:  IF ICF=F THEN
      STEP
      ELFF
      CO
      END)
```

SPECIFICATIONS

ICE-51 Operating Requirements

Intellec® Microcomputer Development System
(64K RAM required)

System console

Intellec® Diskette Operating System (single or
double density) ISIS-II v. 3.4 or later

Equipment Supplied

- Printed circuit boards (2)
- Emulation buffer box, Intellec interface cables,
and user-interface cable with 8051 emulation
processor
- Crystal power accessory
- Operating instructions manual
- Diskette-based ICE-51 software (single and dou-
ble density)

Emulation Clock

User's system clock (1.2 to 12 MHz) or ICE-51
crystal power accessory (12 MHz)

Environmental Characteristics

Operating Temperature: 0° to 40°C

Operating Humidity: Up to 95% relative humidity
without condensation.

Physical Characteristics

Printed Circuit Boards

Width: 12.00 in. (30.48 cm)

Height: 6.75 in. (17.15 cm)

Depth: 0.50 in. (1.27 cm)

Buffer Box

Width: 8.00 in. (20.32 cm)

Length: 12.00 in. (30.48 cm)

Depth: 1.75 in. (4.44 cm)

Weight: 4.0 lb (1.81 kg)

Electrical Characteristics

DC Power Requirements (from Intellec system)

$V_{CC} = +5V, +5\%, -1\%$

$I_{CC} = 13.2A \text{ max}; 11.0A \text{ typical}$

$V_{DD} = +12V, \pm 5\%$

$I_{DD} = 0.1A \text{ max}; 0.05A \text{ typical}$

$V_{BB} = -10V, \pm 5\%$

$I_{BB} = 0.05A \text{ max}; 0.01A \text{ typical}$

User plug characteristics at 8051 socket

Same as 8031, 8051, or 8751, except that the user
system will see an added load of 25 pF capaci-
tance and 50 μA leakage from the ICE-51 emulator
user plug at ports 0, 1, and 2.

ORDERING INFORMATION

Part Number Description

MCI-51-ICE	8051 Microcontroller In-Circuit Emulator, cable assembly and interactive diskette software
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